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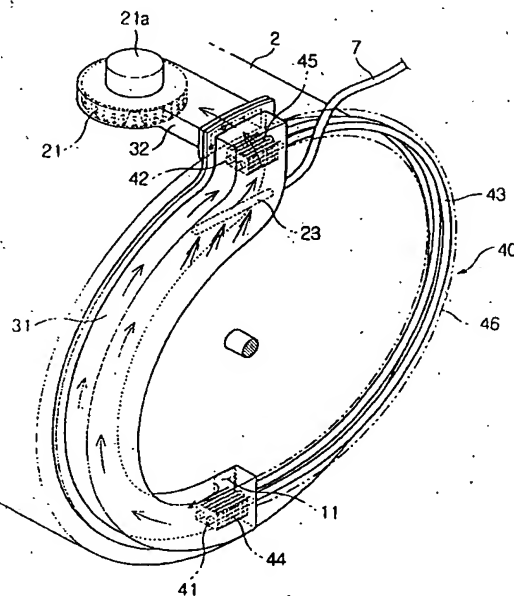
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(54) Washing machine

(57) A washing machine is disclosed. It includes a drum (2) containing a rotatably mounted tub (3) to receive laundry to be washed and a laundry drying unit (20) for drying washed laundry comprising an air duct (30) having each end in communication with the interior of the drum (2) and a blower fan (21) mounted in the duct (20) to circulate air therethrough and back into the drum (2) during a drying cycle. The drying unit (20) includes a condensing element (23) and a heater (22) in the duct (30) operable to remove moisture and heat the air, respectively, before it passes back into the drum (2). The drying unit (20) also comprises means (40) for recovering heat from the air in the duct (30) before it reaches the condensing element (23) and for transferring the recovered heat back to the air after it has passed the condensing element (23).

FIG. 2



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Description

[0001] The present invention relates to a washing machine including a drum containing a rotatably mounted tub to receive laundry to be washed and a laundry drying unit for drying washed laundry comprising an air duct having each end in communication with the interior of the drum and a blower fan mounted in the duct to circulate air therethrough and back into the drum during a drying cycle, the drying unit also including a condensing element and a heater in the duct operable to remove moisture and heat the air, respectively, before it passes back into the drum.

[0002] In a conventional front loading type of drum washing machine, a rotary tub is mounted in a housing so as to rotate clockwise and counterclockwise about a horizontal axis to agitate laundry placed within the rotary tub to which water for washing the laundry is supplied.

[0003] The rotatably tub is disposed within a drum and a door is hingedly mounted to a front of the drum to enable clothes to be placed in, and removed from, the rotary tub.

[0004] One type of conventional drum washing machine is provided with a clothes-drying unit to dry wet clothes after washing. A clothes-drying unit includes an air duct installed around an outer surface of the drum in communication with the interior of the drum in which a blower fan and a heater is mounted. A condensing nozzle is also provided in the air duct to remove moisture from high temperature humid air flowing from the water tub after passing through the wet clothes disposed in the drum, thus forming lower temperature dry air.

[0005] The drying cycle beings after the wash cycle and spin drying cycle have been completed. When the drying-mode begins, both the blower fan and the heater installed in the air duct are turned on and the low temperature dry air flowing from an area around the condensing nozzle passes through the heater becoming heated and changing into high temperature dry air. The dry air is, thereafter, introduced into the drum and passes through the laundry in the rotary tub, removing moisture therefrom. As the high temperature dry air passes through the laundry, the dry air is humidified, becoming high temperature humid air. This humid air flows to the area around the condensing nozzle, becoming low temperature dry air again. The above-described cycle of the clothes-drying unit is repeated for a predetermined time period until the clothes are dried to a desired level.

[0006] A conventional drum washing machine incorporating a clothes-drying unit of the type described above has several drawbacks, as will now be described. When the high temperature humid air flowing from the laundry in the rotary tub passes through the area around the condensing nozzle, the temperature of the air is substantially reduced by cold water which is sprayed from the condensing nozzle to condense the moisture of the humid air. Consequently, the drum washing machine must be provided with the large capacity heater to

change the low temperature dry air into high temperature dry air resulting in excessive consumption of electricity. Furthermore, as it is necessary to heat air using the large capacity heater in every cycle, the time required in the drying-mode operation is undesirably increased.

[0007] Typically, the drying cycle is performed over a relatively long period of time despite varying in dependence on the quantity of the clothes to be dried. However, as a large capacity heater must be used in a conventional drum washing machine, excessive power is consumed making in uneconomical.

[0008] A washing machine according to the present invention is characterised in that the drying unit comprises means for recovering heat from the air in the duct before it reaches the condensing element and for transferring the recovered heat back to the air after it has passed the condensing element.

[0009] In a preferred embodiment, said means for recovering heat from the air in the duct before it reaches the condensing element and for transferring the recovered heat back to the air after it has passed the condensing element comprises a heat pipe, each end of the heat pipe extending into the duct on opposite sides of the condensing element.

[0010] Preferably, the heat pipe has an intermediate, thermally insulated portion extending outside the duct between said ends for the transfer of heat from one end of the heat pipe to the other.

[0011] Advantageously, at least one end of the heat pipe is provided with a plurality of heat transfer fins located within the duct.

[0012] An embodiment of the invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 is a perspective view of a drum washing machine provided with a clothes-drying unit, according to an embodiment of the present invention; Figure 2 is a perspective view of a part of the drum washing machine of Figure 1 illustrating an arrangement of both an air duct and a plurality of heat pipes provided at a rear end of the drum of the washing machine;

Figure 3 is a sectional view of the drum washing machine of Figure 1 illustrating a drying-mode operation of the drum washing machine, wherein air circulates through the clothes-drying unit and the drum to dry wet clothes.

[0013] As illustrated in the drawings, the drum washing machine with the clothes-drying unit of the present invention includes a housing 1. A drum 2 is mounted in the housing 1 to receive water for washing therein. A rotary tub 3 having a perforated sidewall is mounted for rotation about a horizontal axis within the drum 2. The drum washing machine further includes a drive motor 4 to rotate the rotary tub 3 during a washing-mode oper-

ation and a spin-drying mode operation wherein clothes in the rotary tub 3 are washed and spin-dried.

[0014] Both the drum 2 and the rotary tub 3 have open fronts to allow a user to put laundry into the rotary tub 3 and remove it therefrom. A door 5 is hingedly mounted to a front of the housing 1 to enable the front of both the drum 2 and the rotary tub 3 to be opened or closed. A plurality of lifters 6 are transversely arranged on an inner surface of the perforated sidewall of the rotary tub 3 spaced at regular intervals to repeatedly agitate and lift clothes in the rotary tub 3, along with wash water to a position of a predetermined height, in accordance with rotation of the drum 2, and allow them to drop under gravity thereby washing the clothes.

[0015] A water supply hose 7 to supply wash water from an external water source into the drum 2, and a detergent container 8 to add a detergent contained therein to the supplied wash water are disposed within the housing 1. A drain hose 10 with a drain pump 9 is provided at a bottom of the cabinet 1 to facilitate the draining of wash water from the drum 2 to outside when necessary.

[0016] A clothes-drying unit 20 is installed on the drum 2 and includes an air duct 30 on the outer surface of the drum 2 in communication with an interior of the drum 2, thus forming a closed air circulation system with the drum 2. The clothes-drying unit 20 further includes a blower fan 21 to circulate the air through the closed air circulation system, and a heater 22 to heat the circulated air to a desired temperature, thereby drying the wet clothes using the heated air. In addition, a condensing nozzle 23 is provided in the air duct 30 to condense moisture laden in the high temperature humid air, flowing from the water tub 2 after passing through clothes in the rotary tub 3, to generate low temperature dry air. The clothes-drying unit 20 further includes a plurality of heat pipes 40 which recover heat from the high temperature humid air flowing from the drum 2, and transfer the recovered heat to an upper end of the first duct part, wherein the low temperature dry air flows from an area around the condensing nozzle 23.

[0017] The air duct 30 of the clothes-drying unit 20 has a first duct part 31 and a second duct part 32. The first duct part 31 of the air duct 30 is arranged at a rear end of the drum 2 to reduce the humidity of the air flowing from the clothes contained in the rotary tub 3. The second duct part 32 is arranged at a top of the water tub 2 to heat the air flowing from the first duct part 31, thus changing the humid air into the high temperature dry air, prior to feeding the air into the drum 2.

[0018] The first duct part 31 is connected at a lower end thereof to a first connection hole 11 provided at a bottom of the rear end of the drum 2, such that the first duct part 31 communicates with the interior of the drum 2. The first duct part 31 extends from the first connection hole 11 to the top of the rear end of the drum 2 while being curved along a first half part of an edge of the rear end of the drum 2, thus having an arc-shaped appear-

ance.

[0019] The second duct part 32 is connected, at the top of a rear end of the drum 2 to an upper end of the first duct part 31. The second duct part 32 axially extends from the top of the rear end of the drum 2 to a front end of the drum 2, and is connected to a second connection hole 12 provided at a front end of the drum 2.

[0020] Each of the heat pipes 40 is arranged at the rear end of the drum 2 while being inserted at a lower end 41 thereof into the lower end of the first duct part 31 to a predetermined length, and being inserted at an upper end 42 thereof into the upper end of the first duct part 31 to a predetermined length. An intermediate part 43 of each of the heat pipes 40 between the lower and upper ends 41 and 42 extends along a second half part of the edge of the rear end of the drum 2, thus having an arc-shaped appearance, which is curved in a direction opposite to the curved direction of the first duct part 31.

[0021] The lower and upper ends 41, 42 of each of the heat pipes 40, respectively arranged in the lower and upper ends of the first duct part 31, are provided with a plurality of first and second heat transfer fins 44, 45 which are spaced apart from each other at regular intervals. The first and second heat transfer fins 44, 45 enlarge heat transfer surfaces of the lower and upper ends 41, 42, thus allowing the ends 41, 42 to efficiently recover and transfer heat relative to the air flowing around the ends 41, 42 in the first duct part 31. In the embodiment of the present invention, the heat pipes 40 and the heat transfer fins 44, 45 are preferably made of a light material having high thermal conductivity, such as aluminium.

[0022] The intermediate parts 43 of the heat pipes 40 which are exposed to an outside of the first duct part 31, are covered with a thermal insulation material 46 to prevent heat dissipation therefrom. Due to the thermal insulation material 46, the heat, recovered at the lower ends 41 of the heat pipes 40, is efficiently conducted to the upper ends 42 through the intermediate parts 43, without significant heat loss.

[0023] The condensing nozzle 23, connected to the water supply hose 7, is arranged at a position under the upper ends 42 of the heat pipes 40 in the upper end of the first duct part 31. The condensing nozzle 23 sprays cold water in the upper end of the first duct part 31 to form a water curtain covering an entire sectional area of the upper end of the first duct part 31, thus condensing the moisture laden in the humid air flowing upward along the first duct part 31 into droplets which drop due to gravity. The humid air flowing around the condensing nozzle 23 thus becomes low temperature dry air.

[0024] When high temperature humid air flowing from the drum 2 passes through the lower end of the first duct part 31, heat is transferred from the high temperature humid air to the lower ends 41 of the heat pipes 40 through the first heat transfer fins 44. That is, the lower ends 41 of the heat pipes 40 arranged in the lower end of the first duct part 31 recover the heat from the high

temperature humid air flowing from the drum 2. The temperature of the humid air flowing in the lower end of the first duct part 31 is thus reduced, while the temperature of the lower ends 41 of the heat pipes 40 is increased. The recovered heat is conducted from the lower ends 41 of the heat pipes 40 to the upper ends 42 through the intermediate parts 43. When the low temperature dry air flowing from the area around the condensing nozzle 23 passes around the heater upper ends 42 of the heat pipes 40, heat is efficiently transferred from the heater upper ends 42 to the low temperature dry air through the second heat transfer fins 45, thereby increasing the temperature of the dry air, before the dry air is introduced into the second duct part 32.

[0025] Both the blower fan 21 and the heater 22 are installed in the second duct part 32 communicating with the first duct part 31. The blower fan 21 is rotated by a fan motor 21a to circulate air in the closed air circulation system, while the heater 22 heats the circulated air. In the embodiment of the present invention, the heater 22 is a heating coil, which is arranged along an entire width of the second duct part 32, so that the heater 22 dissipates heat to the air flowing around the heater 22 when the heater 22 is turned on.

[0026] Therefore, the primarily heated dry air which flows from the upper end of the first duct part 31 is secondarily heated by the heater 22 in the second duct part 32, thus being changed into the high temperature dry air, prior to being introduced into an interior of the rotary tub 3 through the second connection hole 12 provided at the front end of the drum 2.

[0027] The drying mode operation of the drum washing machine having the above described construction will be described herein below.

[0028] When the clothes contained in the rotary tub 3 are completed washed with the supplied wash water in the wash cycle, a rinse cycle, and a spin-drying cycle, the drying cycle starts in order to dry the clothes. When the drying cycle starts, the rotary tub 3 rotates at a low speed, and, at the same time, the blower fan 21 and the heater 22 of the clothes-drying unit 20 are turned on.

[0029] When the blower fan 21 of the clothes-drying unit 20 is turned on, the air passing through the heater 22 in the second duct part 32, is changed into a high temperature dry air, for example, dry air of about 120°C and 50% relative humidity, prior to being introduced into the interior of the rotary tub 3 through the second connection hole 12 provided at the front end of the water tub 2. While high temperature dry air passes through the wet clothes in the rotary tub 3, the air vaporizes the moisture from the wet clothes and is changed into the high temperature humid air, for example, humid air of about 80°C and 100% relative humidity.

[0030] The high temperature humid air flows from the rotary tub 3 into the lower end of the first duct part 31 through the perforations of the rotary tub 3 and the first connection hole 11 provided at the rear end of the drum 2. In the lower end of the first duct part 31, the lower

ends 41 of the heat pipes 40 absorb heat from the high temperature humid air through the first heat transfer fins 44, thus recovering the heat. The high temperature humid air in the lower end of the first duct part 31 is thus changed into the intermediate temperature humid air, for example, humid air of about 60°C and 100% relative humidity.

[0031] The intermediate temperature humid air flows from the lower end to the upper end of the first duct part 31, and comes into contact with the cold water sprayed from the condensing nozzle 23 arranged in the upper end of the first duct part 31. Therefore, moisture laden in the intermediate temperature humid air is condensed into droplets by the cold water, so that the intermediate temperature humid air is changed into the low temperature dry air, for example, dry air of about 40°C and 50% relative humidity.

[0032] In such a case, the droplets formed by condensing the moisture of the intermediate temperature humid air flow down along an inner surface of the first duct part 31, along with the cold water sprayed from the condensing nozzle 23, and are discharged into the interior of the drum 2 through the first connection hole 11. The water is, thereafter, drained from the drum 2 along with the wash water during a draining-mode operation of the drum washing machine.

[0033] The heat recovered from the high temperature humid air at the lower ends 41 of the heat pipes 40 through the first heat transfer fins 44, is transferred to the upper ends 42 of the heat pipes 40 through the intermediate parts 43 which are covered with the thermal insulation material 46. Therefore, the heat at the second heat transfer fins 45 provided at the upper ends 42 of the heat pipes 40 increases.

[0034] Meanwhile, the low temperature dry air flowing from the area around the condensing nozzle 23 passes through the second heat transfer fins 45 provided on the upper ends 42 of the heat pipes 40 at the position above the condensing nozzle 23, and is combined with the recovered heat at the upper ends 42 of the heat pipes 40 through the second heat transfer fins 45. The low temperature dry air is thus primarily heated and changed into the intermediate temperature dry air, for example, dry air of about 60°C and 50% relative humidity. Thereafter, the intermediate temperature dry air passes through the second duct part 32 having the heater 22, thus being secondarily heated and changed into the high temperature dry air. The above described circulation of the air is shown by the arrows in Figure 3, and is repeated for a predetermined time period, thus quickly drying the clothes contained in the rotary tub 3.

[0035] As is apparent from the above description, the present invention provides a drum washing machine, which has a clothes-drying unit with a plurality of heat pipes. The heat pipes recover, during a drying-mode operation of the drum washing machine to dry clothes, heat from high temperature humid air just after the high temperature humid air comes out of a water tub, and com-

bines the recovered heat with low temperature dry air flowing from an area around a condensing nozzle. Therefore, the clothes-drying unit effectively preheats the air just before the air is introduced to a heater, thus saving electricity during the drying-mode operation. In addition, the clothes-drying unit of the drum washing machine quickly increases a temperature of the air, thus saving time during the drying-mode operation.

[0036] Although an embodiment of the present invention has been shown and described, it would be appreciated by those skilled in the art that changes may be made in this embodiment without departing from the principles of the invention, the scope of which is defined in the claims and their equivalents.

Claims

1. A washing machine including a drum (2) containing a rotatably mounted tub (3) to receive laundry to be washed and a laundry drying unit (20) for drying washed laundry comprising an air duct (30) having each end in communication with the interior of the drum (2) and a blower fan (21) mounted in the duct (30) to circulate air therethrough and back into the drum (2) during a drying cycle, the drying unit (20) also including a condensing element (23) and a heater (22) in the duct (30) operable to remove moisture and heat the air, respectively, before it passes back into the drum (2), **characterised in that** the drying unit (20) comprises means (40) for recovering heat from the air in the duct (30) before it reaches the condensing element (23) and for transferring the recovered heat back to the air after it has passed the condensing element (23).
2. A washing machine according to claim 1, wherein said means for recovering heat from the air in the duct before it reaches the condensing element and for transferring the recovered heat back to the air after it has passed the condensing element comprises a heat pipe (40), each end (41,42) of the heat pipe (40) extending into the duct (30) on opposite sides of the condensing element (23).
3. A washing machine according to claim 2, wherein the heat pipe (40) has an intermediate thermally insulated portion (43) extending outside the duct (30) between said ends (41,42) for the transfer of heat from one end (41) of the heat pipe (40) to the other (42).
4. A washing machine according to claim 3, wherein at least one end (41,42) of the heat pipe (40) is provided with a plurality of heat transfer fins (44,45) located within the duct (30).
5. A drum washing machine comprising a water tub, a rotary tub rotatably installed in the water tub, and a clothes-drying unit to dry clothes contained in the rotary tub, wherein the clothes-drying unit comprises an air duct to form a closed air circulation system in cooperation with the water tub so as to circulate air through the closed air circulation system, a blower fan, a heater, and a condensing nozzle installed in the air duct, and a heat pipe to recover heat from air having a high temperature and a high humidity before the air reaches the condensing nozzle, and to combine the recovered heat with air having a low temperature and a dry state after the air having a high temperature and a high humidity passes through the condensing nozzle.
6. The drum washing machine according to claim 5 wherein the air duct comprises a first duct part arranged at a rear end of the water tub, such that the first duct part communicates with an interior of the water tub at a bottom of the rear end of the water tub, and extends upward from the bottom to a top of the rear end of the water tub along an edge of the rear end of the water tub, and a second duct part extending from the rear end to a front end of the water tub, such that the second duct part communicates at a rear end of the water tub with the first duct part, and communicates at a front end of the water tub with the interior of the water tub.
7. The drum washing machine according to claim 6 wherein the condensing nozzle is installed in the first duct part, and both the blower fan and the heater are installed in the second duct part.
8. The drum washing machine according to claim 7 wherein the heat pipe extends upward from the bottom to the top of the rear end of the water tub so as to be opposite to the first duct part, with a lower end of the heat pipe being arranged in a lower end of the first duct part, and an upper end of the heat pipe being arranged in an upper end of the first duct part, so that the heat pipe recovers the heat from the air having the high temperature and the high humidity which flows in the lower end of the first duct part, and transfers the recovered heat to the upper end of the first duct part and combines the recovered heat with the air having the low temperature and the dry state which flows in the upper end of the first duct part.
9. The drum washing machine according to claim 8 wherein the heat pipe is covered with a thermal insulation material at an intermediate part thereof, thus transferring the recovered heat from the lower end to the upper end thereof, without significant heat loss.
10. The drum washing machine according to claim 8

wherein the upper and lower ends of the heat pipe are each provided with a plurality of heat transfer fins which are spaced apart from each other at regular intervals, thus recovering and transferring the heat relative to the air flowing around the upper and lower ends of the heat pipe.

11. The drum washing machine according to claim 10 wherein the heat pipe and the heat transfer fins are made of aluminium.

12. A drum washing machine comprising a water tub, a rotary tub rotatably installed in the water tub, and a clothes-drying unit to dry clothes contained in the rotary tub, wherein the clothes-drying unit comprises an air duct forming a closed air circulation system with the water tub so as to circulate air through the closed air circulation system, a blower fan, a heater, a nozzle installed in the air duct, and at least one heat pipe recovering heat at a lower end of the air duct from air having high temperature and high humidity and transferring the heat to an upper end of the air duct and combining the heat with air having a low temperature and a dry state.

13. The drum washing machine according to claim 12 wherein the air duct comprises a first duct part arranged at a rear end of the water tub, such that the first duct part communicates with an interior of the water tub at a bottom of the rear end of the water tub, and extends upward from the bottom to a top of the rear end of the water tub along an edge of the rear end of the water tub and a second duct part extending from the rear end to a front end of the water tub, such that the second duct part communicates at a rear end thereof with the first duct part, and communicates at a front end thereof with the interior of the water tub.

14. The drum washing machine according to claim 13 wherein the nozzle is installed in the first duct part, and both the blower fan and the heater are installed in the second duct part.

15. The drum washing machine according to claim 12 wherein the heat pipe is covered with a thermal insulation material at an intermediate part thereof, thus conducting the recovered heat from the lower end to the upper end of the air duct, without significant heat loss.

16. The drum washing machine according to claim 12 wherein upper and lower ends of the heat pipe are each provided with a plurality of heat transfer fins spaced apart from each other at regular intervals, recovering and transferring the heat flowing around the upper and lower ends of the heat pipe.

17. The drum washing machine according to claim 16 wherein the heat pipe and the heat transfer fins are made of aluminium.

18. The drum washing machine according to claim 12 wherein the blower fan and the heater are installed in the second duct part.

19. The drum washing machine according to claim 18 wherein the blower fan is rotated by a fan motor circulating air in the closed air circulation system.

20. The drum washing machine according to claim 12 wherein dry air flowing from an upper end of the first duct part, is heated by the heater in the second duct part, prior to being introduced into an interior of the rotary tub.

21. The drum washing machine according to claim 13 wherein the at least one heat pipe is arranged at a rear end of the water tub inserted at a lower end of the first duct part and at an upper end of the first duct part.

22. The drum washing machine according to claim 13 wherein an intermediate part of the at least one heat pipe extends along a second half part of an edge of a rear end of the water tub, curved in a direction opposite to a curved direction of the first duct part.

23. A drying-mode method of a drum washing machine, the method comprising circulating high temperature dry air through a rotary tub producing high temperature humid air, recovering heat from the high temperature humid air through at least one heat pipe, combining the recovered heat with low temperature dry air flowing from the rotary tub, reheating the combined air producing high temperature dry air, and recirculating the high temperature dry air through the rotary tub.

24. A drum washing machine comprising a clothes-drying unit including a plurality of pipes, wherein the pipes recover, during a drying-mode operation of the drum washing machine, heat from high temperature humid air after the high temperature humid air comes out of a water tub, and combined the recovered heat with low temperature dry air flowing from an area around a condensing nozzle.

FIG. 1

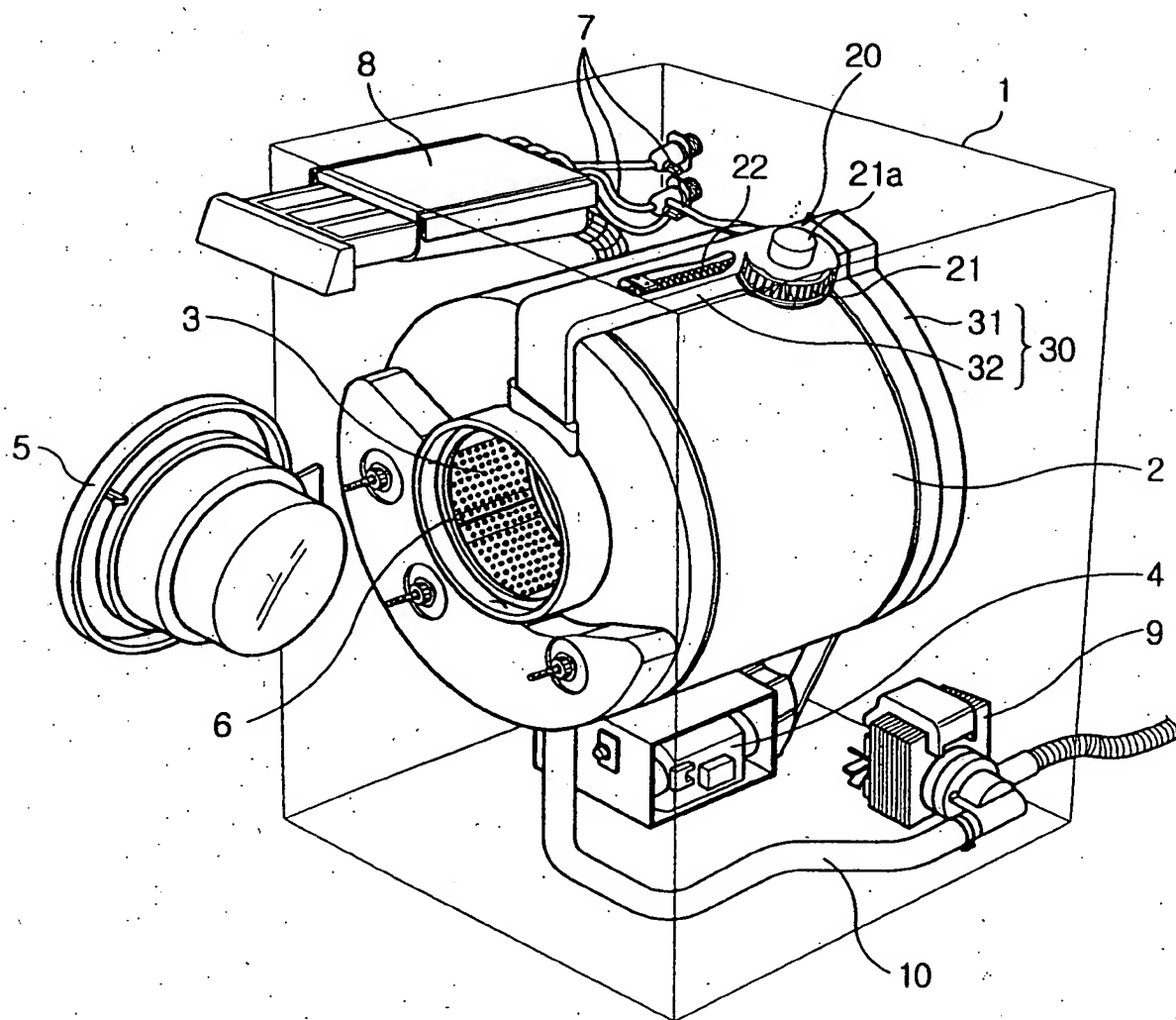


FIG. 2

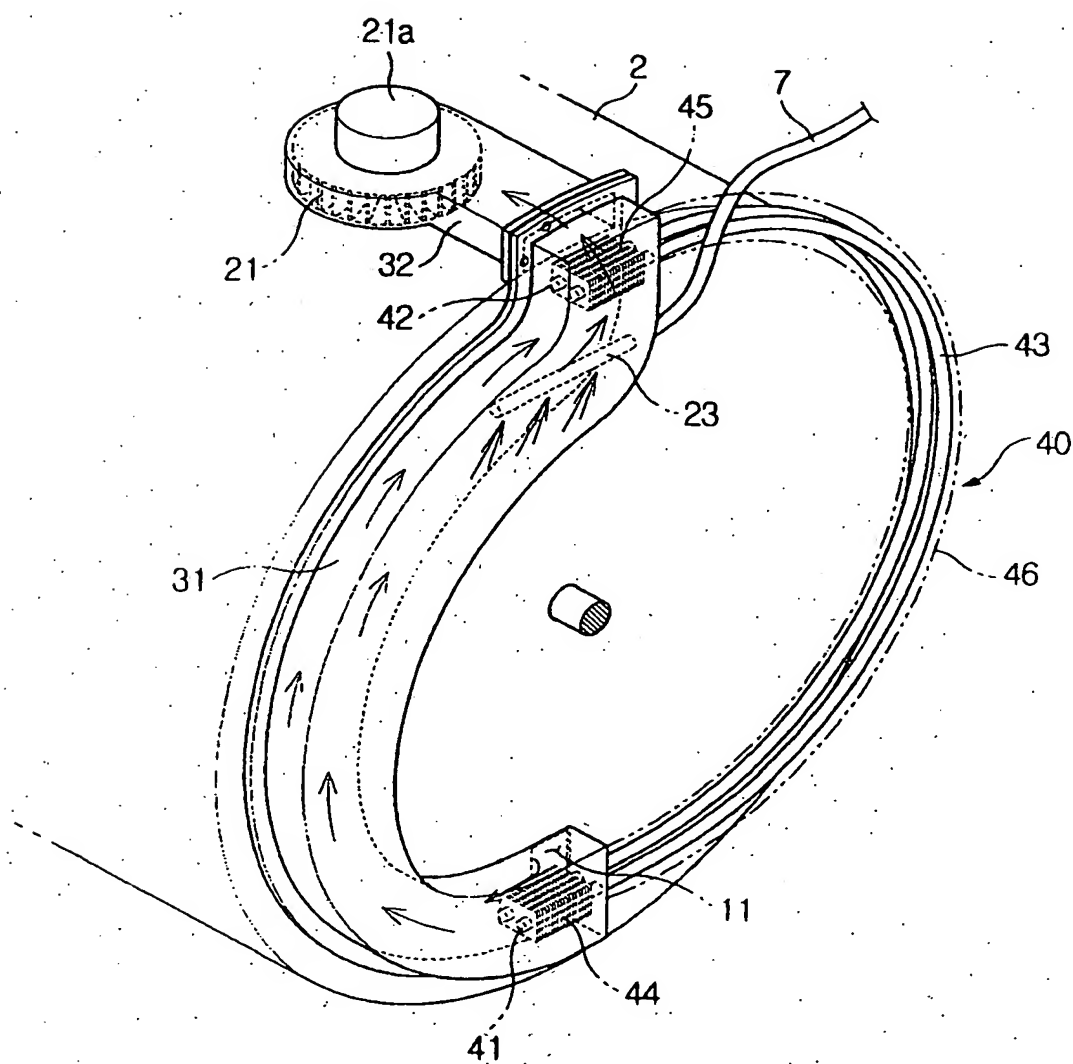
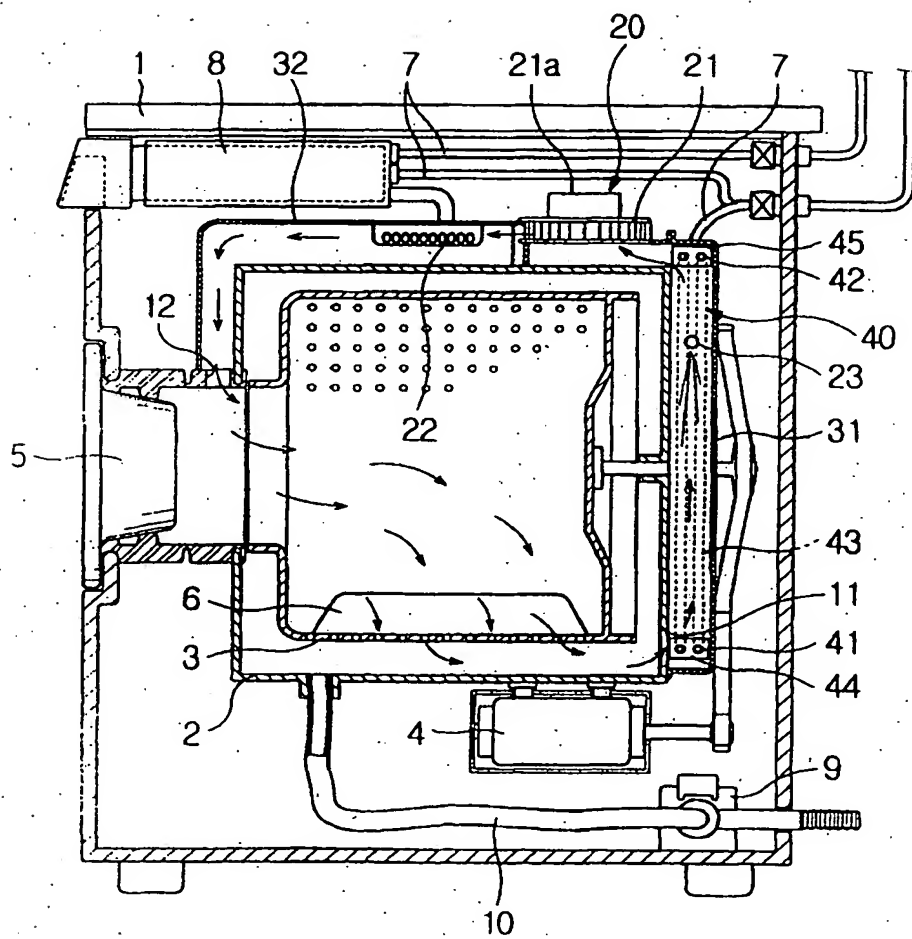


FIG. 3





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